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Notes on Wastage of Non-Parasitic Origin in Stored Apples.

PART II.

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1. Superficial and Lenticel Scald.
2. Jonathan Spot.
3. Lenticel Blotch.
4. Split Core and Mouldy Core.
5. Fungal Rots.
6. Wastage in Australian Apples Exported Overseas.
7. Literature Cited.

1. Superficial and Lenticel Scald.

Superficial Scald.

This superficial browning of the skin occurs principally in yellow varieties and has been met, in our experiments, on Granny Smith and Dunns, and to a much smaller extent on Cleopatra. It may develop as brown to almost black irregular spots or blotches, or as a general discoloration involving only the skin, and perhaps a few layers of cells beneath (Fig. 1, Pl. 1). In any case, it is removed when the fruit is peeled. Though unsightly and affecting the selling value, it does not normally affect the quality or keeping condition of the fruit.

Scald does not develop within the first two months or so of storage, and a thorough ventilation towards the end of this period tends to remove any subsequent liability. About August, and occasionally earlier in Western Australia, scald commences to appear on susceptible varieties, not specially treated, when removed from cold storage. From then onwards, the amount of scalding becomes more severe. In bad cases, it may appear while the fruit is still in store, but, in general, it follows the removal to higher temperatures.

Susceptibility to scald is increased with the immaturity of the fruit, the temperature of storage, and with a delay in placing in cold store if packed and closely stacked. Sunburn, even when hardly noticeable, appears to predispose apples to scald. We have noted this particularly with Granny Smith. Susceptibility is reduced if the apples are properly mature, if they are placed loosely in cases and in open stacks in well-ventilated sheds for seven to ten days before cold storing, if cold-stored loose in cases and removed for a thorough ventilation after about five to six weeks and then returned to store, or if wrapped in anti-scald wrappers. It is generally accepted that scald is due to the excessive concentration in the storage atmosphere of the gases produced by the fruits themselves.

Fruit wrappers impregnated with an odourless mineral oil, first used by Brooks, Cooley, and Fisher (5), are a very effective means of control up to a point. The wrappers absorb the gases and prevent the injury therefrom until, after long storage, they can take up no more. The fruit may then rapidly become affected. For Granny Smith, the variety which has given most trouble in Western Australia, largely because the trade demand is for green and somewhat immature

fruit, the following alternative procedures are suggested:—(1) Place the fruit loose in cases, which are then stacked loosely in a well-ventilated shed to allow plenty of air movement. After seven to ten days pack, using oiled wrappers, and then place in cold store. Or (2) stack for seven to ten days as before, and then cold-store loose in cases. After five to six weeks, remove to shed, pack in anti-scald wrappers, and return to store.

It is regrettable that two diseases are known as scald. The present form should be called superficial scald, as suggested by Tiller (18), to distinguish it from that form of breakdown known as deep scald. The two are distinct in appearance and origin.

The following results in relation to superficial scald were obtained in our experiments:—

Superficial Scald on Granny Smith, in Sulphite Wrappers (Karragullen, Western Australia).

Picked.	Percentage developed in two weeks after cold storage for—	
	Ten Weeks.	Six to Seven Months.
12.3.29 ..	Nil ..	52 (severe)
26.3.29 ..	Nil ..	51 (severe)
23.4.29 ..	Nil ..	53 (slight)

The figures indicate that the number of apples affected was not altered by the maturity of the fruit, but the falling off in severity was very marked. When sold in open market on 26th September, that picked 26th March obtained 15s. 9d. per bushel, as against 17s. 6d. for fruit picked 23rd April. The effect of ventilation is shown by the fact that a duplicate lot picked 23rd April, removed to an open shed for three weeks in July, and then returned to cold store for the remainder of the period, sold for 18s. 9d., as against 17s. 6d. per bushel for the continuously stored fruit. All the fruit in this experiment was packed within 24 hours of picking, using ordinary sulphite wrappers. The ventilated fruit was only 28 per cent. scalded, and that but slightly.

Superficial Scald on Dunns, in Sulphite Wrappers (Karragullen, Western Australia).

Picked.	Percentage developed in two weeks after cold storage for—	
	Ten Weeks.	Six to Seven Months.
12.2.29 ..	Nil ..	100 (very severe)
12.3.29 ..	Nil ..	100 (severe)
26.3.29 ..	Nil ..	11 (slight)

Slight scald developed in Cleopatras after six to seven months' storage in 1929 to the extent of 10 per cent in fruit picked 12th February, and only 1 per cent. in that picked 9th April. Lenticel scald was also present even more severely, falling to 5 per cent. in the last picking. Severe scalding, associated with shrivelling, occurred in 1930 on Cleopatras stored in sheds or cellars, both in our experiments and in commercial fruit. It was very slight in cold-stored fruit.

Lenticel Scald.

This is a form of scald which appears as a brown spot affecting the lenticels and the immediately adjoining skin (Fig. 2). It occurs alone, or in association with the normal form. Both forms have been noted on Granny Smith and Cleopatra, and the spotting form on Dougherty.

Affected lenticels are subject to fungal invasion. This has been noted in Cleopatra and Dougherty.

Lenticel scald is apparently identical with the lenticel spot of Kidd and Beaumont (10), which was recognized as being a spotting form of scald by Kidd and West (11), as the former authors had shown it to be controlled by anti-scald wrappers. It has been recorded on Yellow Newton and Bramley's seedling in England.

Clearly to distinguish this type of spot from Jonathan spot, with which it has apparently been confused by some workers, the name Lenticel Scald has been adopted.

Superficial Scald Generally.

So far as information is available, neither form of superficial scald occurs as a defect of Australian apples in Europe. If this is true, it is probably due to the long time factor required for scald, as such apples are rarely held at low temperatures for more than ten weeks. American apples in Europe have frequently been cold-stored for four to six months before they are sold, and, in consequence, scald may be a serious defect. Arkansas, Grimes, Newtown, Rome Beauty, Winesap, and York Imperial are recorded as susceptible in the United States of America (15). European trade reports indicate that the following were also affected in 1930:—Ortley, Ben Davis, Gano, Starks, and Baldwin. Jonathan, in the United States of America, is practically immune. In Canada, Grimes and Wagener are recorded as very susceptible, Rome Beauty moderately, and Jonathan and Delicious only slightly (14).

Victorian experiments in 1923 and 1924 (1 and 2) resulted in records of scalding on Rome Beauty, Stone Pippin, Buncombe, Rymer, Winter Majetin, and Jonathan. Unfortunately, no distinction was made between deep and superficial scald, and consequently these records cannot be used, though the descriptions and experimental results suggest that superficial scald occurred on all except Jonathan.

2. Jonathan Spot.

Confusion with Other Diseases.

Considerable confusion exists as to the exact identity of this disease. This was noted by Tiller (19), but he concluded that the different spotting troubles known under this name were probably "one disease developed under slightly varying circumstances." A study of the available literature, combined with that of the spotting diseases met in our experiments, indicates that at least three have been known as Jonathan spot. These are distinguished as under:—

Jonathan Spot.
Lenticel Blotch.
Lenticel Scald (Lenticel Spot of Kidd and Beaumont).

The confusion appears to have originated in the original description of Scott and Roberts (16), which is indefinite enough to cover all three. This vagueness appears to have led workers, following the statement of these authors that "a lenticel usually forms the centre of each spot," to recognize any non-parasitic spotting disease as Jonathan spot if it involves the lenticels. Strange to say, the form which we, with Plagge and Maney (15), and Tiller (18), regard as Jonathan spot, because it

is the form most frequent on that variety, is only casually associated with the lenticels. In the other two forms, the association is constant and specific.

Jonathan Spot.

The following description is based upon our experience and the descriptions of Plagge and Maney in North America, and Tiller in New Zealand.

Jonathan spot is a non-parasitic disease of certain varieties of red, or partially-red, apples, notably Jonathan and Esopus Spitzenberg. It is characterized by rather ill-defined greenish-yellow to brown or almost black spots, streaks, or blotches (Fig. 3). They are hardly depressed, and involve only the epidermal tissues. Though they may occur anywhere on the apple, they are much more frequent on the red than on the non-flushed surfaces, and not uncommonly more towards the stem than the calyx end. The lighter-coloured spots occur on the yellow surfaces, and the darker on the red. Though lenticels are necessarily involved in the larger spots and blotches, they are frequently absent from the smaller. Indeed, there is no evidence of any causal relation between the two.

Jonathan spot may develop on highly-coloured fruit on the tree, or on windfalls, but is mainly a storage trouble. Liability increases with the length of storage and with the intensity of the red colouring, and consequently with the maturity of the fruit when picked. Its onset does not affect the eating or keeping quality of the fruit. In our experience, the spots are not subject to fungal invasion. References in literature to rotting following spot appear to refer to lenticel blotch or scald. The spotting form affects the market value of fruit, and is apparently confused at times with bitter pit. The streaky form is confined to the red surfaces, and is often taken as part of the normal colouration.

The relations of Jonathan spot to fruit size, storage temperature, and storage humidity are somewhat uncertain, owing to apparently contradictory evidence. Plagge and Maney (15) found no consistent relation between size of fruit and susceptibility. McAlpine (13) noted that more small fruits were affected than large, an observation supported by our experiments in 1929.

Jonathan Spot in Jonathans (Karragullen, Western Australia).

Picked. Percentage developed in relation to size of fruit.

	Size 2¼ inches.		Size 2½ inches.		Size 2¾ inches.	
	B.	A.	B.	A.	B.	
12.2.29	7	Nil	2	Nil	—	
19.2.29	—	Nil	10	Nil	—	
26.2.29	—	1	18	2	10	
5.3.29	—	7	43	10	—	
12.3.29	—	9	46	4	30	
19.3.29	63	51	54	17	—	

Counts made two weeks after removal from A., ten weeks, and B., six to seven months, in cold store. The mean storage temperature ranged from 33° to 36° F. No spot developed in shed-stored fruit at 50° to 90° F.

In 1929, a year of intense colouring in Jonathans, spot was common. In 1930, the fruits were less coloured, and the colouring was less intense. No spot was noted either in our experiments or in commercial fruit. Plagge and Maney found that practically the same percentage of apples were affected at 40° as at 32° F., but the spotting was more severe at the higher temperature. Adam (1), in Victoria, and Tiller (18), in New Zealand, found no relation to temperature. Conflicting results have also been obtained in relation to storage humidity. Tiller found no consistent relation to variation in humidity at 32°, while Plagge and Maney obtained more spot at higher than lower humidities at both 30° and 80°.

In addition to Jonathan and Spitzenberg, Plagge and Maney have recorded Jonathan spot on Rome Beauty and King David. Other records of its occurrence on different varieties appear unsafe owing to the uncertainty as to the identification of the disease.

Jonathan spot has been recorded as occurring in Australian apples in England, particularly in Jonathans from Western Australia (9). Here, again, there is some doubt as to the identity of the disease. The amount present in 1927 in the Western Australian fruit is stated to have fallen from 15 per cent. in the earlier and more immature shipments, to 5 per cent. in the later and more mature. In an unpublished report from the Low Temperature Research Station of the British Department of Scientific and Industrial Research, it was recorded as occurring in Victorian Jonathans shipped towards the end of February, 1928, and therefore immature, an opinion confirmed by the presence of bitter pit in some of the lines. This association with immaturity suggests that the trouble was lenticel blotch rather than Jonathan spot.

3. Lenticel Blotch.

This name is proposed for a spotting disease (Fig. 4) found by us on Jonathans and Spitzenberg in Western Australia, and on Spitzenberg from Victoria. It appears to be, at least in part, the Jonathan spot of Brooks and Cooley (4), McAlpine (13) and Carne, Pittman and Elliott (6). Fig. 3 in the last publication, entitled "Jonathan spot on Spitzenberg," in reality illustrates blotch. McAlpine gives an excellent colour plate (13) of blotch, which he apparently regarded as a form of bitter pit. As stated under Jonathan spot, it is possible that the disease recorded as spot on Australian apples in England (9) may be really blotch.

Though it has a superficial resemblance to spot, blotch differs markedly in detail. The lesions tend to be developed towards the calyx end of the fruits, and without any definite relation to the coloured areas. In many examples, the non-flushed areas have been the more affected. Each isolated lesion has a lenticel in its centre. They are larger than the spots of the spotting form of Jonathan spot, and are frequently, almost typically, confluent, forming irregular blotches up to 1 cm. or more in greatest diameter. They are sharply defined, and definitely depressed though involving only the skin and a shallow layer of cells beneath (Fig. 5). Fungal invasion is not infrequent, and the spots then take the circular form common to fungal rots.

Nothing is known as to the cause of this defect, but its common association with bitter pit suggests that they have something in common. In our experiments, it has occurred mainly in shed-stored

fruit (see below), and only to a slight extent in fruit placed in cold store within a week of picking. It has occasionally been noted in Jonathans during the inspection of fruit for export.

Lenticel Blotch and Bitter Pit in Jonathans Stored in Shed, Karragullen, Western Australia.

(From same trees in both years.)

Picked.	Total per cent. Blotch.	Total per cent. Bitter Pit.	Total per cent. Pit & Blotch	Per cent. Blotch only.
12.2.29 ..	4 ..	37 ..	? ..	?
19.2.29 ..	18 ..	29 ..	? ..	?
26.2.29 ..	13 ..	18 ..	8 ..	5
5.3.29 ..	6 ..	13 ..	5 ..	1
12.3.29 ..	14 ..	13 ..	6 ..	8
19.3.29 ..	6 ..	11 ..	3 ..	3
30.1.30 ..	2 ..	6 ..	2 ..	Nil.
13.2.30 ..	3 ..	11 ..	2 ..	1
27.2.30 ..	2 ..	0 ..	0 ..	2

Apples 2½ inches diameter in 1929, 2–2½ inches in 1930, except pick of 13.2.30, which had 2¼–3 inch fruit. The pit in this picking was distributed as follows:—2¼ inches, 2 per cent.; 2½ inches, 5 per cent.; 2¾ to 3 inches, 30 per cent.

4. Split Core and Mouldy Core.

Some varieties of apples are subject to a rupturing of the core, which is usually confined to the cartilagineous endocarp. Not infrequently, however, the rupture extends to the fleshy parts of the core, and even into the cortex. Such varieties have usually an open calyx tube, which allows the spores of various common rot fungi to enter the core cavities. When the ruptures extend into the flesh, the fungi may attack it and set up a general rot. Cleopatra is a variety very subject to core ruptures, and in our experience with it the following conditions have been found:—

(*a*) A transverse cracking of the endocarp, indicated by white streaks known as "woolly stripe" (7). The white streaks are produced by loosely-packed protruding cells. As the fruit matures, these cells turn brown. Woolly stripe is so common in Cleopatra as to be a normal characteristic of the variety, at least as grown in Western Australia. No evidence has been obtained that fungi ever succeed in growing into the flesh of the fruit through these cracks in the endocarp.

(*b*) A pulling apart of the five sections of the endocarp, so that instead of it consisting of five closed seed compartments, a five-lobed open cavity is formed. This condition is known as "hollow core." Not infrequently, weak fungal growths may be found in the cavity, discolouring its walls, but not penetrating the flesh or affecting the selling value of the fruit.

(*c*) The development of longitudinal cracks at the points of the endocarp lobes in hollow-cored apples (Fig. 6). These ruptures occur most frequently at the calyx end, at the top of each lobe. Less frequently they develop at the stem end. As a result of this splitting of the endocarp, the flesh of the core is more or less exposed, and may itself be ruptured. In the absence of fungi, the ruptured flesh becomes brown and corky, and no further deteriora-

tion of the fruit results. This is the condition referred to by Smith (17) as "an undescribed core disease," and by us as "flesh rupture" (7). The name "split core" is now suggested for any rupture of the endocarp involving the fleshy parts of the core (Fig. 6). In our experience, the percentage of split core in Cleopatra does not vary greatly in any season, but the amount of flesh rupture, i.e., the size of the cracks, is markedly increased in light as compared with heavy crops. In 1930, the Cleopatra crop was relatively light, and the development of split core became economically important, leading to the rejection of fruit, both in the orchard and during the inspection of export fruit. Marked split core not only affects the apples commercially because of the large core cavities and flesh ruptures extending in bad cases almost to the skin, but also because of the high susceptibility of the affected apples to "mouldy core." Fungi attack the flesh from within the endocarp, and cause rots which finally extend to the skin.

In severe split core, the greatest rupture tends to take place in the same plane on opposite sides of the core, so that two carpels split badly, dividing the fruit into two halves—one with one end, and the other with two more or less normal seed cavities. In more severe cases, one or two more carpels split, forming ruptures at right angles to the first. Splitting occurs some time before the fruit reaches full growth, with the consequence that badly affected fruit tends to become irregular in shape. This fact enables many to be discarded by the packer, and is the only external aid to the recognition of split core during the inspection of export fruit. The irregularities take the form of depressions at the calyx end, in the same planes as the cracks, while the fruit as a whole tends to be flattened adjacent to the cracks.

The following table indicates the relation of size of crop to the development of mouldy core. The fruit in 1928 and 1930 came from the same trees; that in 1929 from different and larger trees in the same orchard. In no year did the rainfall reach 1 inch in any month from December to March.

Percentage Split Core and Mouldy Core in Relation to Size of Crop (Cleopatra), Karragullen, Western Australia.

Stored in Shed, 50° to 90° F.

	1928.	1929.	1930.
Average crop per tree ..	8 bushels	14 bushels	4 bushels
Stored	6 weeks	5 weeks	8 weeks
Percentage split core only	23	20	22
Percentage mouldy core	2	1	6

In 1930, 50 per cent. of the fruit with mouldy core had rotted to the skin.

Mouldy core has also been recorded in Australia in Annie Elizabeth and London Pippin (8 and 12).

5. Fungal Rots.

Fungal rots in apples usually follow mechanical injuries or storage diseases. The principal exception is mouldy core, which has its origin in defects developed during the growth of the fruit. The onset of fungal rots in land stores and during shipment overseas is related to the temperature and humidity of the storage atmosphere.

Injuries, in the main, are due to carelessness in packing and in handling the fruit from the time of picking to its final disposal through retail channels. The storage diseases which predispose fruits to fungal rotting are mainly breakdown, lenticel scald, and blotch.

Contact with the commercial handling of fruit soon makes evident the many opportunities for bruising and other injury. From the time of picking, the risk of injury is always present, and the wonder is, not how much has occurred, but rather how little. Provided the fruit is carefully handled to the packing bench, the best insurance against injury, under the conditions at present existing, is good packing. Over-tight packing is a frequent cause of bruising, especially in hardwood cases. Loose packing, on the other hand, is liable to cause bruising when the boxes are roughly handled, besides causing complaints as to get-up and shortage of weight. To reduce the danger of bruising when nailing on the lids of the boxes, several precautions can be used. Corrugated strawboards, especially on the tops and bottoms, will reduce the pressure on the fruit. The strawboards should be carefully placed. Cases have been noted where they have slipped to one side and the edge has cut into the outer row of fruit on the opposite side. When nailing up, the box should be supported on its ends, so as to allow the bottom board to bulge when the lid presses on the fruit.

Low temperatures tend to reduce and high humidities in the storage air to encourage rotting.

6. Wastage in Australian Apples Exported Overseas.

From reports by the trade, by the High Commissioner and Agents-General, by the Empire Marketing Board (9), and published and unpublished reports by Dr. Barker (3) of the Low Temperature Research Station of the Food Investigation Board of the British Department of Scientific and Industrial Research, it is very evident that a serious amount of wastage occurs in Australian apples exported overseas. It develops not only during transit, but also in the period between unloading and retail distribution. The principal defects are bitter pit, breakdown, and fungal rots. Relatively minor defects are skin-marking, caused by fungi like black spot and by spray burn; insect pests, as codlin moth; and non-parasitic diseases, such as deep scald, freezing injury, Jonathan spot (?), and brown heart. Superficial scald apparently does not occur.

We have shown that breakdown comprises a number of forms, each associated with specific conditions. The evidence available indicates that those originating in bitter pit and water-core are the most important in exported fruit. Brown heart, caused by an excessive accumulation of carbon-dioxide in the holds, is now rare and inexcusable. At one time it was the predominant form of breakdown, but liability has almost disappeared with the introduction of controlled ventilation into routine practice in refrigerated holds. Fungal rots have their origin mainly in mechanical injuries or defects of physiological origin, such as breakdown, lenticel blotch, and split core. They are checked by both low temperature and low humidity of the atmosphere. The main market defects are thus primarily due to the defective pre-storage condition of the fruit and to defective handling, though they may be aggravated by the storage temperature and atmosphere. The main primary defects operate as follow:—

Bad packing and careless handling leads to bruising and fungal rots.

Premature picking leads to poor colour; if the fruit is held too long at ordinary temperatures, before or after shipping, to shrivelling and slack packs; to bitter pit and subsequent liability to breakdown and fungal rots; to lenticel blotch and liability to fungal rots.

Water-core in fruit when picked leads to breakdown and fungal rots, and probably to deep scald.

Split core in fruit when picked leads to liability to mouldy core and rotting.

Over-maturity of the fruit when picked may lead to the serious occurrence of Jonathan spot in susceptible varieties.

Over-maturity of the fruit when picked or when placed in the refrigerated holds increases its liability to bruising, and consequently, to fungal rots.

To eliminate these primary causes of wastage, the following precautions should be taken:—

1. The fruits should be clean, sound, of good shape and colour for the variety, and sufficiently mature when picked. While avoiding immaturity, with its liability to cause shrivelling, bitter pit, and lenticel blotch, care should be taken to avoid over-maturity. Over-mature apples are unduly liable to bruising, fungal rots, water-core with subsequent breakdown, and to develop a mealy texture with a lack of flavour and freshness.

2. Special care should be taken, especially with light crops of quick-maturing varieties like Jonathan, to avoid an undue amount of water-core to which they are liable when maturing. It is better to pick such varieties on the immature side in seasons when water-core is prevalent if they are to be exported, but if the market conditions are reasonably good, it would be much safer to market them locally.

3. The fruit should be carefully handled, graded, and packed. Grading should be on the basis of colour as well as size, as this leads to uniformity of appearance, maturity, and keeping quality. Over-tight and loose packing should be equally avoided. Corrugated strawboards should be used at least on bottoms and tops, and care taken when nailing down to avoid bruising.

4. Several pickings should be made to secure uniformity of maturity and colour. If congestion of work prevents picking as the fruit becomes ready, yellow varieties among the earlier sorts, like Dunns and Cleopatra, should be left on the trees and picking concentrated on the poorer keeping varieties like Jonathans, Cox's Orange Pippin, and Gravenstein. These latter, owing to their high liability to shrivelling, bitter pit, breakdown, and poor colour when picked immature and to bruising and breakdown when over-mature, have a very short safe picking period. In Western Australia, the main crops of these varieties have a safe picking period of not more than a week under the normal conditions of temperature for February and March. Cleopatra, though pit liable, is breakdown-resistant. When immature, it suffers less from colour defects than the red varieties. When ready, picking may be delayed two or three weeks, or until loss by windfalls becomes excessive. Dunns and Granny Smith lose their pit-liability and will mature normally if picked while still hard and nearly full green. They may consequently be picked over a relatively long period. In short, apples

should be picked according to their varietal characteristics. The picking programme should be based upon the quick-maturing poor-keeping varieties, and the others should be fitted in as convenient. In planting an orchard, one aim should be to provide a series of varieties cropping more or less in succession, rather than to have groups of varieties maturing together. If export is intended, care should be taken to select the best export varieties and to avoid those which may be already overplanted, such as Jonathan.

7. Literature Cited.

(1) Adam, D. B.—Experiments on the storage of fruits. *Jour. Dept. Agr. Vict.*, 21, 234-241 and 371-375, 1923.

(2) Adam, D. B.—Cool storage of fruit. *Jour. Dept. Agr. Vict.*, 22, 577-590, 1924.

(3) Barker, J.—Wastage in Australian fruit exported to England. *Jour. Coun. Sci. & Ind. Res. Aust.*, 1, 261-267, 1928.

(4) Brooks, C., & Cooley, J. S.—The effect of temperature, aeration, and humidity on Jonathan spot and scald of apples in storage. *Jour. Agr. Res.*, 11, 287-317, 1917.

(5) Brooks, C., Cooley, J. S., & Fisher, D. F.—Apple scald and its control. U.S. Dept. Agr. Farm Bull. 1380, 1-17, 1928.

(6) Carne, W. M., Pittman, H. A., & Elliott, H. G.—Bitter pit in apples. Coun. Sci. & Ind. Res. Aust. Bull. 41, 1-88, 1929.

(7) Carne, W. M., Pittman, H. A., & Elliott, H. G.—Notes on certain disorders of Cleopatra apples. *Jour. Coun. Sci. & Indust. Res. Aust.*, 2, 49-52, 1929.

(8) Darnell Smith, G. P., & Mackinnon, E.—Fungus and other diseases of the apple and pear. New South Wales Dept. Agr. Farm Bull. 99, 1-45, 1915.

(9) Empire Marketing Board—Report on Fruit Investigations during the Australian and New Zealand Season, 1927. Spec. Rept. 3, 1-65, 1928.

(10) Kidd, M. N., & Beaumont, A.—An experimental study of the fungal invasion of apples in storage. *Ann. App. Biol.*, 12, 14-33, 1925.

(11) Kidd, F., & West, C.—Functional diseases of apples in cold storage. Gt. Brit. Dept. Sci. & Indust. Res. Food Inv. Bd. Spec. Rept. 23, 1 15, 1925.

(12) McAlpine, D.—Bitter Pit Investigations. 1st Prog. Rept. Govt. Printer, Melb., 1-197, 1912.

(13) McAlpine, D.—Bitter Pit Investigations. 5th Prog. Rept. Govt. Printer, Melb., 1-144, 1916.

(14) Palmer, R. C.—Report of Superintendent, Expt. Stn., Summerland, British Columbia, for 1927, 4-29, 1928.

(15) Plagge, H. H., & Maney T. J.—Apple Storage Investigations. Iowa Agric. Expt. Stn. Bull. 222, 106-168, 1924.

(16) Scott, W. M., & Roberts, J. W.—The Jonathan Fruit Spot. U.S.D. Agr. Bur. Plant. Indust. Circ., 587, 1917.

(17) Smith, A. J. M.—Brown Heart in Aust. Apple Shipments. Gt. Brit. Dept. Sci. & Ind. Res. Food Inv. Bd. Spec. Rpt., 22, 1-28, 1925.

(18) Tiller, L. W.—Cold Storage of Fruit. New Zealand Dept., Sci. Ind. Res. Bull. 16, 1-23, 1929.

(19) Tiller, L. W.—Cold Storage Investigations, Season 1926. Cawthron Inst., New Zealand, Chemistry Dept. Bull., 6, 1-16, 1927.

PLATE 1

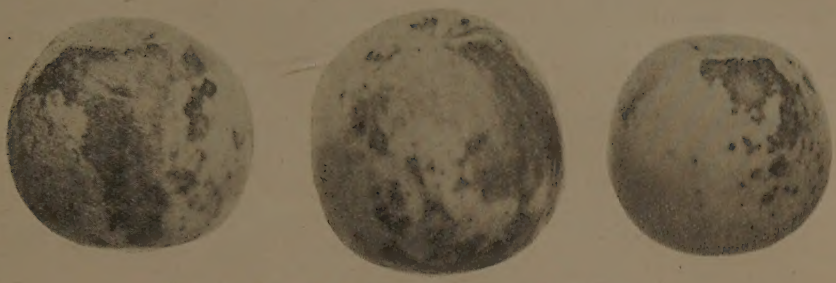

FIG. 1.—Superficial Scald on Granny Smith apples.

FIG. 2.—Lenticel Scald on Granny Smith apples.

FIG. 3.—Jonathan Spot on Jonathan apples.

PLATE 2.

FIG. 4.—Lenticel Blotch on Jonathan apple.

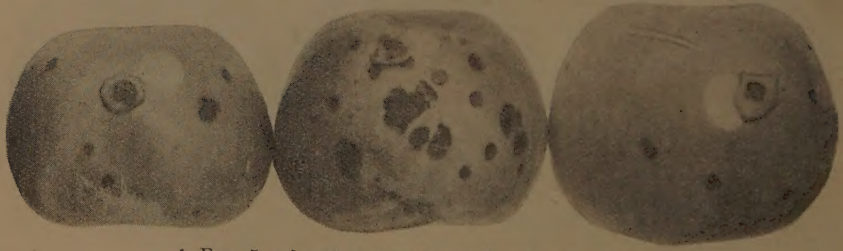

FIG. 5.—Lenticel Blotch on Jonathan apples.

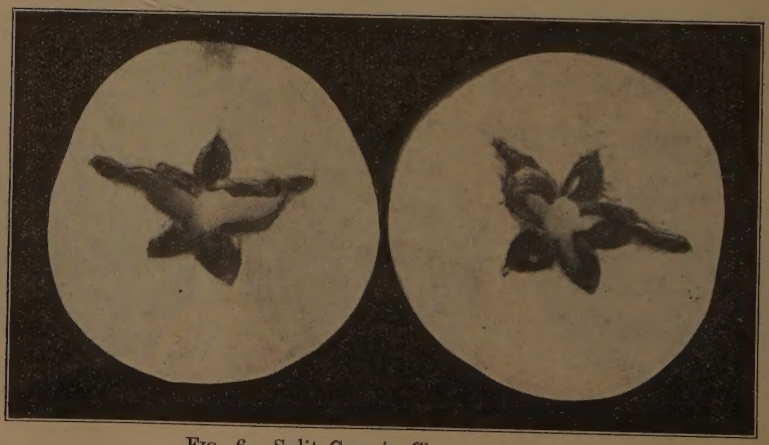

FIG. 6.—Split Core in Cleopatra apple.

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